EXECUTIVE SUMMARY

In this draft report, the Air Resources Board (ARB/Board) staff provides a technical evaluation for public comment of 37 options that may accelerate further statewide locomotive and localized locomotive and non-locomotive railyard emission reductions. This technical evaluation of each option addresses the technical feasibility, potential emission reductions, costs, and relative cost-effectiveness. The purpose of this document is to provide a sound technical basis for the ongoing dialogue on how best to achieve further emissions reductions of oxides of nitrogen (NOx) and diesel particulate matter (PM or diesel PM).

This draft report is intended to provide an initial technical assessment of various options that are available or may be available in the near future to accelerate and provide additional emissions reductions from locomotives and major railyards in California. It is not intended to serve as an implementation blueprint, as it does not evaluate which agency or agencies may have authority to implement such options. The document also does not evaluate what role, if any, the availability of public funding might play in assuring earlier or further reductions.

Following receipt and evaluation of the public comments, ARB staff will develop a final report on the technical evaluation of the options. Following the completion of that report, ARB staff will develop a second draft report for public comment that addresses possible implementation mechanisms. The range of mechanisms includes direct regulation, incentive funds, voluntary actions by the railroads, and enforceable agreements with the railroads.[1] This second report will draw on the results of the previous technical evaluation. In developing the second report, ARB staff will again seek public comments.

This Executive Summary presents the options evaluated and the preliminary results of the technical evaluation. The options identified may not represent all of the possible options available and staff is seeking comments on other potential options. In addition, the Executive Summary highlights several priority options for consideration. Additional details and background information is presented in the main report and in the Appendices.

A. BACKGROUND

Since the early 1990's, the Air Resources Board (ARB) has worked to develop innovative ways to provide significant emission reductions beyond federal locomotive emissions standards. The ARB has employed a combination of implementation mechanisms such as state regulations, voluntary agreements, and incentive programs to further reduce locomotive and railyard emissions beyond federal requirements. These innovative efforts achieved reductions in spite of specific federal preemptions to

[1] The Board adopted Resolution 05-40 on July 21, 2005, concerning any future enforceable agreements. For a copy of the resolution, see http://www.arb.ca.gov/railyard/ryagreement/b-rslution.pdf . For related Board meeting transcript, see http://www.arb.ca.gov/board/mt/mt072105.txt .

regulate locomotive emissions in the federal Clean Air Act and other statutory programs.

The ARB continues to work with affected stakeholders to identify innovative approaches that will build on past efforts to reduce railyard and statewide locomotive emissions. ARB staff is seeking collaborative approaches. To that end, the ARB staff hopes the technical evaluation of options can be used as a basis for discussions with railroads and other stakeholders to accelerate further reductions from locomotives and railyards, or as a blueprint for use of public incentive funding, or for both purposes.

B. Summary of Technical Options Evaluated

The technical evaluation considered 37 options for reducing emissions from locomotives and from non-locomotive sources at railyards. In most cases, there was sufficient information to determine technical feasibility, potential emission reductions, costs, and relative cost-effectiveness. In other options, staff notes where such data do not exist.

Staff evaluated technical feasibility based on the state of development of a particular technology or operational measure. Technical feasbility was also evaluated based on the ability to implement a given technology or option within existing or future locomotive or railyard operations. In a number of cases, staff assessed when a technology was developed or could become be developed and when the technology could become U.S. EPA certified or ARB verified.

Staff generally calculated potential emissions reductions on a per unit basis. With available data, potential emissions reductions were calculated for regional and statewide benefits. Please note that some options are dependent on the implementation of other options and potential emissions reductions may not be additive when determining emission benefits. Costs were primarily based on capital costs, but in some cases included operational, maintenance, and replacement costs when applicable or where the information was available.

Cost-effectiveness was typically calculated by dividing total costs by the amount of NOx and PM pollutants reduced, over a specified range of years of use or useful life. The pollutants reduced were generally both diesel PM and NOx, but there are a few exceptions when information was not available. Staff tried to develop a simple cost-effectiveness range based on pollutants reduced in 2005 versus, in many cases, 2015 or 2020 to show the relative benefits of the various options.

This simple methodology for cost-effectiveness will ensure the highest degree of consistency when comparing different types of technologies or measures. This approach is also flexible enough for reviewers to recalculate the cost-effectiveness based on another methodology (e.g., the Carl Moyer Program). However, as this is a technical evaluation document, and not an implementation document, staff tried to avoid adopting a particular program cost-effectiveness methodology.
Tables ES-1 through ES-4 provide an assessment of the 37 options evaluated to further reduce and accelerate locomotive and non-locomotive emissions reductions. The

assessments are based on the following criteria: technical feasibility, potential emissions reductions, capital and other costs, and cost-effectiveness. The options are also assessed based on a potential schedule for implementation in California: near-term (within 5 years), mid-term (within 10 years), and long-term (generally within 15 years). Note that the option numbers correspond to the option numbers listed in the main body of the report.

Table ES-1
Options to Accelerate Further
Locomotive Emissions Reductions

Option #	**Near-Term Options (up to 5 years)**	**Emission Reductions Statewide (tons per day)**		**Cost-Effectiveness (NOx+PM) ****	**Costs (Millions)**
		PM	**NOx**		
Locomotive Replacements or Engine Repowers					
1	Replace 152 older switch locomotives with new ULESL switch locomotives ($1.5 million/unit)	0.30	6.6	$2-5/lb (10-20 years)	$230
5	Repower 400 older MHP locomotives with new LEL engines ($1 million/unit); or	1.25	23.0	$1-2/lb (10-20 years)	$400
	SUBTOTAL	**1.55**	**29.6**	**$1-5/lb**	**$630**
6	A possible alternative to Option #2, replace up to 200 of the 400 older MHP locomotives with new MHP gen-set locomotives ($2 million/unit)	0.63	13.3	$2-4/lb (10-20 years)	$400
Locomotive Remanufacturing Options – Less Expensive Alternatives to Options #1 and #5					
4	Remanufacture 152 older switch locomotives to meet U.S. EPA Tier 0 Plus emission standards * ($250,000/unit)	0.22 *	2.2 *	$1-2/lb (10-20 years)	$38
8	Remanufacture 400 older MHP locomotives to meet U.S. EPA Tier 0 Plus emission standards * ($250,000/unit)	1.0 *	13.0 *	$0.50-1/lb (10-20 years)	$100
	SUBTOTAL	*1.22 **	*15.2 **	*$0.5-2.50/lb*	*$138*
* Note: Estimated emissions reductions are highly dependent on whether the railroads choose to remanufacture older locomotives. ** Cost-effectiveness ranges are based on10 to 20 years of useful life and may not add up precisely due to rounding.					
	Mid-Term Options (up to 10 years)				
Locomotive Aftertreatment (DPF and SCR) – Enhanced Benefits from Options #1 and #2					
2	Retrofit 244 ULESL switch locomotives with DPF and SCR ($200,000/retrofit)	0.04	1.0	$3-7/lb (10-20 years)	$50
7	Retrofit 400 LEL or gen-set MHP locomotives with DPF and SCR ($500,000/retrofit)	0.18	6.8	$2-4/lb (10-20 years)	$200
	SUBTOTAL	**0.22**	**7.8**	**$2-7/lb**	**$250**
	TOTALS (Options 1,5,2,7)	**1.77**	**37.4**	**$1-7/lb**	**$880**

Table ES-1 (Continued)
Options to Accelerate Further
Locomotive Emissions Reductions

Option #	Long-Term Options (up to 15 years or more)	Emission Reductions Statewide (tons per day)		Cost-Effectiveness (NOx+PM) **	Costs (Millions)
		PM	NOx		
New Tier 4 Locomotive Replacement or Tier 4 Nonroad Engine Repowers					
3	Repower 244 ULESL switch locomotives with new Tier 4 nonroad engines ($200,000 incremental cost difference)	0.01	0.6	$5.50-11/lb (10-20 years)	$50
9	Accelerate up to 1,500 Tier 4 interstate line haul locomotives ($3 million/unit) in UP&BNSF national fleet for 600 to operate in California (on any given day)	0.60	16.0	$12-37/lb * (10-30 years)	$4,500
	SUBTOTAL	**0.61**	**16.6**	**$5-37/lb**	**$4,550**
	TOTALS (1,5,2,7,3,9)	**2.38**	**54.0**	**$1-37/lb**	**$5,430**

* May not add up precisely due to rounding. ** Cost-effectiveness based on a range of 10 to 30 years of useful life.

Table ES-2
Options to Accelerate Further
Non-Locomotive Railyard Emissions Reductions
(Diesel Trucks, Cargo Handling Equipment, TRUs, Off-Road, and Stationary)

Option #	Near-Term Options (up to 5 years)	Emission Reductions Statewide (tons per day)		Cost-Effectiveness (NOx+PM)	Costs (millions)
		PM	NOx		
CHE - Yard Trucks/Hostlers – (Replace 322 yard hostlers in 8 intermodal railyards)					
10	LNG Yard Hostlers	-	-	-	$39 ($.12/unit 322 units)
11	Electric Yard Hostlers	0.01[1] (2015)	0.27[1] (2015)	$41/lb (2015) (8 years)	$68 ($.21/unit 322 units)
12	Hybrid Yard Hostlers *	-	-	-	-
CHE – RTG Cranes – (Retrofit/Replace 67 RTGs in 8 intermodal railyards)					
13	Energy Storage Systems	0.0014 (2015)	0.082 (2015)	$9-18/lb (2015) (20 years)	$11-22 ($.16-$.32/ (67 RTGs)
14	Wide Span Gantry Cranes and Non-Locomotive Railyard Electrication Infrastructure Costs	0.023* (2015)	0.79* (2015)	$101/lb (2015) (20 years)	$1,200 (134 WSGs replace 67 RTGs)
Idle Reduction Devices - (Retrofit cargo handling equipment with idle reduction devices similar to those employed on trucks and locomotives)					
15	Idle Reduction Devices (Cargo Handling Equipment)	-	-	-	-
Transport Refrigeration Units (TRUs) (Install at 8 intermodal railyards)					
16	Plug-In Electrification for Transport Refrigeration Units (TRU) – (with necessary non-locomotive railyard electrification)	0.003 (2020)	0.03 (2020)	$2,100/lb (2020)	$500
Drayage Trucks – Ports to Intermodal Railyards (e.g., UP ICTF/BNSF SCIG/UP Oakland)					
17	New 2007 HD Diesel Trucks	NA	NA	NA	$.11/unit
18	LNG HD Drayage Trucks	0.0	0.0002	$96/lb [2] (15 years)	$.21/unit
19	CNG HD Drayage Trucks	0.0	0.0005	$20/lb [2] (15 years)	$.12/unit
20	Electric HD Drayage Trucks	0.0	0.0006	$32/lb [2] (15 years)	$.21/unit

* Staff assumes that railyard non-locomotive electrification and replacement with Wide Span Gantry (WSG) Cranes would nearly eliminate all CHE (i.e., Cranes, Yard Hostlers, and related CHE equipment) emissions.
Note: The 18 railyard HRAs estimated that 2005 CHE railyard diesel PM emissions were 25 tons per year. Staff estimates that the ARB CHE Regulaton will reduce railyard CHE diesel PM emissions by 80 percent by 2015, or to about 5 tons per year.
Note: The 18 railyard HRAs estimated that in 2005 Truck railyard diesel PM emissions were 31 tons per year. Staff estimates that the ARB Port and Intermodal Railyard Drayage Truck regulation may reduce railyard truck diesel PM emissions by up to 90 percent or more by 2015, or to about 3 tons per year.
Note: The 18 railyard HRAs estimated that 2005 TRU railyard diesel PM emissions were 14 tons per year. Staff estimates that the ARB TRU ATCM will reduce railyard TRU diesel PM emissions by 92 percent by 2020, or to about 1 ton per year.
NA – The new 2007 diesel truck PM and NOx emission standards are required in intermodal railyards by 2014 per the CARB Drayage Truck Regulation. 1. Emissions reductions are surplus to the ARB CHE Regulation in 2015.
2. Accounting for just cost-differential between new 2007 HD diesel truck cost-effectiveness would be lowered to: 1) LNG - $46/lb 2) CNG - $2/lb 3) Electric - $15/lb.

Table ES-3
Options to Accelerate Further
Advanced System Emissions Reductions

Option #	Near-Term Options (up to 5 years)	Emission Reductions Statewide (tons per day) PM	NOx	Cost-Effectiveness (NOx+PM)	Costs (millions)
21	ALECS or Hood Technology (All 18 railyards service/ maintenance/ fueling diesel PM emissions – 18 tpy. UP Roseville about 1 tpy in one location of railyard).	0.0027	0.0548	$30/lb (20 years)	$25/unit
22	Locomotive Remote Sensing	*	*	*	$0.25 **
23	Idle Reduction Devices on All Interstate Line Haul Locomotives	*	*	*	$5k-40k/unit
25	GE Electric Hybrid Locomotive	*	*	*	*
27	CARB Diesel Required on All Interstate Line Haul Locomotives Prior to Entering California [1]	0.2	1.0	$15/lb	$0.036/day
28	California Locomotive In-Use Emission Testing	*	*	*	$1 ***

* Staff believes these options will not provide emissions reductions beyond current programs.
** Costs are for one remote sensing device, total costs would depend on number of remote sensing devices procured.
*** Costs are annual costs to test 15 locomotives with SWRi mobile lab – which would be equivalent to the federal in-use locomotive emissions testing program. Does not include the costs for California to develop its own locomotive emissions testing facility.

Option #	Mid to Long-Term Options (up to 10 or 15 years or more)	PM (tons per day)	NOx (tons per day)	Cost-Effectiveness (NOx+PM)	Costs (millions)
24	BNSF Hydrogen Fuel Cell Locomotive	***	***	***	$3.5/ demonstrator
26	Ethanol-Fueled Locomotive	***	***	***	$1.5/unit
30	Maglev from Ports of LA/LB to UP ICTF and proposed BNSF SCIG	0.033	0.66 **	$40-105/lb (15 years)	$300-$800
31	Linear Induction Motors (LIMs) Retrofit of Major Freight Rail Lines in the South Coast Air Basin	0.7 *	14.2 *	$30/lb (30 years)	$10,000
39	Electrification of Major Freight Rail Lines in the South Coast Air Basin	0.7 *	14.2 *	$40/lb (30 years)	$13,000

* Assumes 80 and 70 percent of PM and NOx locomotive emissions are reduced in the South Coast Air Basin.
** Estimated based on a factor of 20 of NOx to PM.
*** Insufficient data. [1] Most of these potential CARB diesel emission reductions would occur between state boundaries and major UP and BNSF refueling depots (e.g., Needles to Barstow, Truckee to Roseville, Yuma, AZ to Colton, CA, Las Vegas, NV to Yermo).

Table ES-4
Options to Accelerate Further
Individual Railyard Emissions and Risk Reductions

Option #	Near-Term Options	Emission Reductions Statewide (tons per day)		Cost-Effectiveness (NOx+PM)	Costs (millions)
		PM	NOx		
32	Build walls around the perimeter of railyards (Serve as barrier to diesel PM emissions)	*	*	*	$2.4/mile
33	Plant trees around the perimeter of railyards (To filter and create barrier to diesel PM emissions)	*	*	*	$.25/mile
34	Install indoor air filtration systems in nearby schools and residents	*	*	*	$1-5k/ central unit
35	Install air monitoring stations near the railyard	*	*	*	$30k/unit $30k annual
36	Enhance state and local locomotive and truck enforcement efforts.	*	*	*	Railyard specific and costs unknown
37	Relocate emissions sources further away from residential receptors	*	*	*	Railyard specific. Costs unknown.

* Staff has no data to estimate potential diesel PM emissions reductions. Also, when emissions reductions may be possible, they would likely be railyard specific – based on specific railyard operations, location of residents to railyards, etc. Without emissions reductions data, staff was not able to calculate cost-effectiveness.

C. Staff Preliminary Recommendations High Priority Options

After reviewing the results of the technical evaluation, staff has identified several high priority options. These options have the potential to achieve significant emissions reductions in the near term either on a railyard-specific basis or a regional basis, or both. Implementation of these options would not preclude other options being pursued. The high priority options are identified in Table ES-5. Table ES-6 represents similar options for the South Coast Air Basin.

Achieving these results will require future collaboration between all stakeholders to develop an implementation mechanism that assures the reductions are achieved in a timely manner. As discussed in the main report, the technology for Option 1 is available; other options may require the development and demonstration of technology. These demonstrations are in progress and staff believes that the technology transfer has a high probability for success. Even so, it is important to recognize that not all of the options can be implemented immediately.

Table ES-5
High Priority Near-Term (By 2014)
Options for the Rest of the State
(Other Than the South Coast Air Basin)

Near-Term Options	Technology Demonstrated	Emission Reductions Statewide (tons per day)		Costs (Millions)
		PM	NOx	
Replace 89 older switch locomotives with new ULESL switch locomotives ($1.5 million/unit)	Yes	0.16	3.8	$134
Repower 250 older MHP locomotives with LEL engines ($1 million/unit)or new MHP gen-set locomotives ($2 million/unit)	In Process	0.78	14.4	$250 to $500
SUBTOTAL		**0.94**	**18.2**	**$384-$634**
Retrofit DPF and SCR onto 105 ULESL switch locomotives ($200,000/retrofit)	In Process	0.02	0.40	$21
Retrofit DPF and SCR onto 250 MHP LEL engines or new gen-set locomotives ($500,000/retrofit)	In Process	0.11	4.25	$125
SUBTOTAL		**0.13**	**4.7**	**$146**
TOTALS		**1.07**	**22.9**	**$530-$780**

*** May not add up precisely due ot rounding.**

Table ES-6
High Priority Options for
Reducing Emissions in the Near Term (By 2014)
in the South Coast Air Basin

Option	Technology Demonstrated	Emission Reductions by 2014 South Coast Air Basin (tons per day)		Costs (Millions)
		PM	NOx	
Replace 63 older switch locomotives with new ULESL switch locomotives ($1.5 million/unit)	Yes	0.14	2.8	$95 *
Repower 150 older MHP locomotives with LEL engines ($1 million/unit) or new gen-set MHP locomotives ($2 million/unit)	In Process	0.47	8.6	$150-$300
SUBTOTAL		**0.61**	**11.4**	**$245-$395**
Retrofit DPF and SCR onto 139 ULESL switch locomotives ($200,000/retrofit)	In Process	0.02	0.60	$28 *
Retrofit DPF and SCR onto 150 MHP LEL engines or new gen-set locomotives ($500,000/retrofit)	In Process	0.07	2.55	$75
SUBTOTAL		**0.09**	**3.2**	**$103**
TOTALS		**0.7**	**14.6**	**$348-$498**

* May not add up precisely due ot rounding.

The proposed locomotive options would provide the largest emissions and risk reductions within railyards, regionally, and statewide. Non-Locomotive railyard electrification, if proven operationally feasible and cost-effective, could potentially nearly eliminate railyard cargo handling equipment emissions. Similarly, were the ALECS or Hood Technology prove to be operationally feasible and cost-effective, it could potentially reduce some stationary locomotive emissions at large locomotive classification and mechanical and servicing railyards. The locomotive options combined could potentially reduce railyard diesel PM risks by up to another 50 percent (e.g., from 100 to 50 in a million).

The eight intermodal railyard drayage trucks emissions are estimated to be about about 3 tons per year in 2015, largely due to the ARB drayage truck regulation. Staff believes advanced systems approaches will become more feasible and cost effective in the future, and may become the ultimate solution to further reduce railyard diesel truck emissions. In the medium-term, employing Maglev or other non-fossil technology (i.e., petroleum based) to move containers from the Ports of Los Angeles and Long Beach to near-dock intermodal railyards could be the least emitting, and could completely replace drayage trucks operating on highways and local arterials.